EFFECT OF SNOW ON WINTER WHEAT IN OHIO.

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SNOWFALL AND WINTER WHEAT.

A considerable fall of snow is generally thought to be favorable for winter grains, especially if it comes late in the spring. A correlation of the amount of snowfall with the yield of winter wheat in three counties in Ohio, as shown in Table 1, seems to controvert this idea and shows that a heavy snowfall in March is detrimental rather than beneficial.

TABLE 1.—*Correlation between snowfall and the yield of wheat, Ohio, 1892–1914.*

Month.	County.	Correlation coefficient.	Probable error.
January	Fulton	0.42	±0.13
February	do	0.12	±0.15
March	do	−0.84	±0.04
Do	Wayne	−0.69	±0.08
Do	Seneca	−0.48	±0.11

This indicates that in northwestern Ohio a heavy snowfall in January is slightly favorable; has little or no influence on the final yield if it comes in February, but a decidedly adverse influence if in March. This unfavorable influence of March snowfall in Fulton County is verified by the showing for Wayne and Senaca counties, both in Northern Ohio.

In fig. 1 the relation between the snowfall in March at Wauseon, Ohio, and the yield of wheat in Fulton County is indicated by the two lines. They show that in nearly every case when the snowfall was above the normal the yield of wheat was below the normal. In 1899 and 1912 especially, when the snowfall was unusually large, the wheat yield during each year was remarkably low. The figures at the left show variations from the average for both yield and snowfall.

In general, a month of heavy snowfall in Ohio is cooler than normal, while a warm March is accompanied by light snowfall. It has been shown [1] that a warm March is decidedly favorable for winter wheat in Ohio. The correlation coefficient between the average March temperature for the State of Ohio and the average yield of winter wheat for Ohio, covering a period of 60 years, is +0.46, with a probable error of ±0.06.

In view of the evident effect of March temperature and the relation between temperature and snowfall the point has been raised that the damaging effect of snowfall in March is more apparent than real and that it is due largely to cool weather.

To determine the real facts we have calculated the partial correlation for the three factors, temperature, snowfall, and wheat yield, as indicated in the following equations:

Let r_{sy} indicate the correlation coefficient for the March snowfall and wheat yield in Fulton County, Ohio, $= -0.84, \pm 0.04$.

Let r_{ty} indicate the correlation coefficient for March temperature and wheat yield in Fulton County, Ohio, $= +0.62, \pm 0.09$.

Let r_{st} represent the correlation coefficient for the March snowfall and temperature in Fulton County, $= -0.678, \pm 0.08$.

[1] Agricultural Meteorology, J. Warren Smith, President's Address, Proceedings of the Ohio Academy of Science, Vol. VI, Part 5.

To eliminate the effect of the temperature and show the influence of the snowfall alone the equation may be written:

$$(1) \qquad r_{sy.t} = \frac{r_{sy} - r_{st}\, r_{ty}}{\sqrt{(1-r_{st}^2)\,(1-r_{ty}^2)}}$$

Inserting the various correlation coefficients and making the necessary calculation, we have $-0.73, \pm 0.07$ as the correlation coefficient between the snowfall in March and

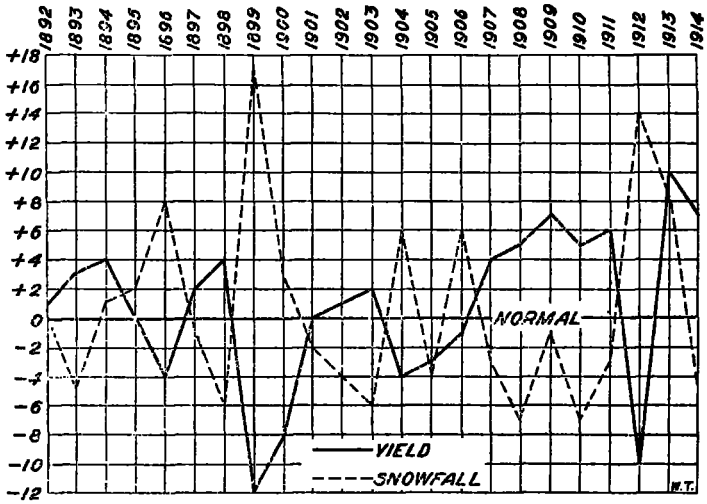

FIG. 1.—Curves showing the relation between the snowfall in March at Wauseon central Fulton County, Ohio, and the yield of wheat in that county. The solid line shows the variation of the yield from the average, in bushels per acre. The broken line indicates the departure of the snowfall from the average in degrees Fahrenheit.

the yield of wheat in Fulton County after eliminating the temperature influence.

The snowfall influence is eliminated from the temperature correlation in a similar manner by the equation:

$$(2) \qquad r_{ty.s} = \frac{r_{ty} - r_{st}\, r_{sy}}{\sqrt{(1-r_{st}^2)\,(1-r_{sy}^2)}}$$

Inserting the values and making the calculation we find the correlation coefficient between the March temperature and wheat yield reduced from $+0.62, \pm 0.09$, to the surprisingly low value of $+0.13, \pm 0.14$, after eliminating the effect of snowfall.

Dot charts, which are not reproduced here, substantiate the above and make plain the dominating influence of the March snowfall as compared with the March temperature. Unfortunately the available record covers only 23 years, but it is believed to be long enough to establish the fact that a heavy snowfall in March is detrimental to winter wheat in northern Ohio. This is substantiated by a chart prepared by Mr. Root for Illinois, but not reproduced in his article.

SNOW-COVERING AND WINTER-WHEAT.

A heavy fall of snow may melt quickly and leave the ground bare a good part of the month. On the other hand, a light total fall may remain on the ground over spells of unfavorable temperature conditions. Hence, the study of the effect of a covering of snow on wheat must be entirely separate from one on snowfall and wheat.

The general opinion is that winter grains should be covered by snow during cold weather and more especially when freezing and thawing conditions prevail. The results of studies in Ohio by the writer and by students taking the advanced course in Agricultural Meteorology at the Ohio State University show little to substantiate this opinion, at least during part of the winter.

A correlation between the number of days with snow on the ground from December to March, inclusive, and the yield of wheat in Fulton County, Ohio, gave a coefficient of only -0.14, ± 0.14. A correlation between the yield of wheat and the number of days in March with freezing weather, while the ground was bare, gave a coefficient of only -0.01. A correlation of the yield with the number of days during the whole winter with the ground bare and the temperature below 20° produced a coefficient of -0.28, ± 0.14. The last gives a slight relation, but the others indicate no real effect of the lack of a snow covering on the yield.

In the spring of 1915 Mr. Harry Roads made a correlation between the number of days with freezing and thawing weather during the whole winter in Clinton County, Ohio, and the yield of wheat, and got a correlation coefficient of only -0.18, or less than two times the probable error. The period covered was 28 years. He did not take the snow covering into account, but as this county is in southern Ohio where there is generally no great amount of snow-covering it shows that freezing and thawing conditions do not have so great an effect upon the yield of wheat as has been thought.

On the other hand, there is some evidence to indicate that wheat has a better prospect if it is not covered by snow during the month of January. A correlation by J. T. Cox between the number of days without a snow-cover when the temperature was below freezing in January and the yield of wheat in Wayne County, Ohio, gave a coefficient of $+0.49$, probable error ± 0.11. He found also that a large temperature range in January was beneficial.

Table 1 showed that a heavy snowfall in January was somewhat beneficial, while the above indicates that a snow-covering in that month may be detrimental. The explanation may be that a heavy snowfall in January melting quickly, as well as freezing and thawing weather while the ground is bare in this month, disintegrates the soil particles and settles the earth around the dormant roots and makes the plants better able to withstand later unfavorable conditions when they begin to develop.

Heaving is one of the most common causes of damage which usually occurs in the spring and is due to alternate freezing and thawing. It is possible, also, that a heavy snow-cover in January produces conditions favorable for smothering the grain, either from a very deep accumulation of snow, or, what is most common, the formation of an ice sheet from the partially melted snow.

The whole subject of winter damage to grains, whether by heaving, smothering, freezing of plants, or physiological drought, and the part that a snow-cover or lack of it, plays is worthy of a most thorough study. The facts given above, although based on too little data, may indicate the direction that the investigation should take.

PROTECTIVE POWER OF SNOW.

"The following observation [at Falling Royd, Hebden Bridge, Yorkshire, England] shows the remarkable extent to which a covering of snow protects the ground and plant life from intense cold. About 6 p. m. on the 13th of January a minimum thermometer was placed on the ground in the center of my lawn here, the temperature then being only a few degrees below freezing. Snow then fell to the depth of 1½ inches. At 11 p. m. the snow had ceased falling, and it was a bright starlight night and very cold. A second minimum thermometer was then placed on the top of the snow. No more snow fell in the night. In the morning the two thermometers recorded the following minimum temperatures: On the top of the snow, 2° F. below zero; under the snow, 24° F., or a difference of 26 degrees."

A. R. Crossley (in Symons's Meteorological Mag., Feb., 1918, 53:20).